Journal of Environment and Earth Science www.iiste.org
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 3, No.1, 2013

Assessment of Wash-Borehole Water Quality in Gombe Metropolis, Gombe State, Nigeria

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Abstract
Groundwater from wash-boreholes in Gombe Metropolis North-Eastern Nigeria was investigated to ascertain its quality status and suitability for drinking and domestic uses. Water samples were collected in the three wards of the Metropolis, namely Tudun Wada (ward A), Pantami (ward B) and Jeka da Fari (ward C). The physicochemical and bacteriological analyses conducted were in accordance with the standard procedures. The mean values for temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), sulphate (SO_4^{2-}), nitrate (NO_3^-), fluoride (F^-), hardness, copper, manganese, total and faecal coliforms were within the permissible limits recommended by the Nigerian Standard for Drinking Water Quality (NSDWQ) and also, below the World Health Organization (WHO) standards with the exception of nitrate (NO_3^-). However, turbidity and nitrite (NO_2^-) in all the three wards, total iron in wards B and C, as well as the phosphate (PO_4^{3-}) in ward C, had mean values above the NSDWQ and also, beyond the WHO standards with the exception of nitrate (NO_3^-). Thus, as a preventive measure to control the health threat associated with consumption of nitrate (NO_3^-), nitrite (NO_2^-), phosphate (PO_4^{3-}) and iron from the water source, wash-borehole water in Gombe Metropolis should only be used for bathing and washing. The study therefore, stresses on the need that public should be provided with an alternative water source for drinking and cooking purposes.
Key words: Wash- borehole, Water quality, Monitoring, Gombe metropolis.

1.0 Introduction

Water is a necessity, a resource and at the same time a major contributory factor in the contamination/pollution problems. As a liquid, it is unique in both its physical and chemical characteristics. Its importance to life, therefore, can never be overemphasized, as it encircles life all round. To maintain good health, water must be kept safe and free of contamination/pollution of any type. Good drinking water supply to Nigerian's teeming populace is a perennial problem that has defied solution. As such, it has often attracted rhetorical commentaries with little or no practical solutions. Therefore, great concern must be given to the quality of drinking water as it is very critical for the overall socio-economic development of any society and, should engage the attention of individuals, groups, government and non-governmental organizations (Adetunde and Glover, 2010). Since the public utilities are simply unable to cope with the demand for qualitative water, alternative source(s) of water must be found. Thus, the frustrated citizenry of Gombe metropolia in north-eastern Nigeria seek for and apply pragmatic solutions that enable them move on with the ordinary simple daily tasks of maintaining simple hygiene and the drinking of clean, clear, odourless and presumably pure water. Often quoted statistics give the impression that urban centres are better off than the rural areas where a large proportion of the population resides, as a result of which much national and international aids are directed to these areas. However, the situation is just as appalling in the cities where there are really no dividing lines between fringes and the city centres. To justify the scenario conspicuously, UNICEF (2010) joint monitoring programme for water supply and sanitation, reported that only 58 percent of Nigerian population has access to improved drinking water supply and sanitation coverage stands at only about 32 percent. This translates that of the estimated population of Nigeria which is about 150 million, about 64 million people are without access to improved drinking water and over 100 million people do not have access to improved sanitation.

The acute water shortage forced many people to drink untreated water obtained from surface and underground sources thereby exposing them to hazardous chemicals and infectious agents. This has made many researchers to focus their attention towards evaluation of physicochemical and microbial characteristics of water supplies (Kamar et al., 2011; Yerima et al., 2008; Akansha et al., 2010; Okonkwo and Okorie, 2011). Gombe Metropolis, the administrative capital of Gombe State provides a good study of the situation. Prior to 1996 when it was made the capital of the state, Gombe Metropolis was a provincial town with a modest population. This has however changed today due to urbanization. And, the major source of drinking water to people living in the Metropolis is processed water from DadinKowa Dam. Although the state government has made a lot of effort to ensure steady supply of this vital resource to the citizenry, but the quantity available to the people at any given time is far from being adequate. This is because the state's Water Board has no installed capacity to meet the city's water demand, as unfortunately, the city's development has long outstripped its distribution network. Epileptic power supplies and other supply problems that militate against water production to design schedules have also been described as impediments. This has led to a situation in which many people resolved to` drill their own wash-borehole or revert to the traditional hand dug wells that were used before the construction of the Dadin Kowa water treatment plant.

This study is therefore very crucial at the moment because of the rapid increase in the number of the wash-boreholes constituting a substantial source of drinking water for public consumption in Gombe Metropolis. The level of nitrates in some part of the Metropolis that are built in reclaimed dumpsites could be high. The consumers are however not aware of such concern as they do not know, rather do not really care for since the groundwater appears clean and clear to their eyes. Worse still, many of these boreholes were constructed without due consideration to the locations of pit latrines and waste dumping sites, which could make the water more susceptible to chemical and microbial contaminants through leaching and percolation, respectively. All these, really cast heavy doubt in the minds environmental scientists and managers on the safety of the already constructed wash-borehole water for public consumption.

Furthermore, the significance of this study lies in the fact that Gombe Metropolis is still a virgin state capital; created just in 1996 and no baseline study on the physicochemical and bacteriological characteristics of wash-borehole water in the Metropolis has ever been carried out. Hence, the data will serve as a reference point to assess any progress that would be made in future when it comes to planning and management of the state's environmentally-based natural and infrastructural resources. Such apart, to monitor the trend and spatial distribution of these contaminants in this environmental compartment and thus, it is essential to obtain and maintain a data base of the proportion of the contaminants in the water which plays host to chemical and many disease causing pathogens. The broad aim of this study was to assess the quality of water obtained from wash boreholes in Gombe metropolis with a view to determining it suitability for drinking and other domestic uses.

2.0 Methodology

2.1 Description of the study Area

The study was carried out in Gombe Metropolis, the capital of Gombe state, situated in the North-Eastern part of Nigeria. The area of this study lay approximately within latitude $10^0 19^/$N and $11^0 02^/$E. It is characterized by a tropical climate with two distinct seasons; a rainy season (May-October) and a dry/harmattan season (November-April). Based on the vegetation classification of Nigeria, the study area falls into Sudan savanna climate. The monthly mean temperature records show a range from 18^0 to 39^0 and annual rainfall of 954mm (Ileoje, 2001). The Metropolis has an estimated population of 319,875 as it was reported in 2006 census (FRN, 2007; Lazarus, 2008).

2.2 Sample collection

Three wards namely Tudun Wada, Pantanmi and Jeka da Fari in Gombe Metropolis were chosen for the purpose of this investigation. In each of the wards, 3 wash-boreholes were randomly selected. 4 water samples (replicates) were collected from each wash borehole using sterile 1000 ml polythene containers. Before collection, the mouth and the outer parts of the borehole taps were sterilized with the flame of a cigarette lighter, and allowed to cool by running the water for about 1 minute. Thereafter, the sample bottles were rinsed with the sample water before filling them. The bottles were held at the bottom while filling, to avoid contamination of water from the hands or fingers (Oparaocha*, et al., 2011*). All the sample containers were kept in ice boxes and brought to the laboratory for analysis.

2.3 Physicochemical and Bacteriological Analysis

Temperature, pH and Conductivity, were directly measured on site using a portable multipurpose pH, Temperature and conductivity field meter. Total Dissolved Solids (TDS) calculated from the conductivity values obtained. Turbidity determined with a HACH 2100 P Turbidity meter. Nitrate, nitrite, sulphate, phosphate and flouride contents were colorimetrically analysed using DR890 Colorimeter. Trace elements – Copper, Iron and Manganese were determined using Atomic absorption Spectrophotometer (AAS, Unicom 969) after extraction with Aqua-regia. Total and faecal coliforms were determined by Membrane Filtration method using

M-Endo-Agar Les (Difco) at 37°C and on MFC Agar at 44°C, respectively.

2.4 Data analysis

Simple descriptive statistics (means and standard deviations) were used to interpret the raw data on the physicochemical and bacteriological parameters generated in the cause of this investigation.

3.0 Results and Discusion

The mean values of physicochemical and bacteriological parameters of the water samples obtained from wash-boreholes in Gombe Metropolis are presented in Table1.

The mean temperature values recorded in water samples were 26.38^{O}C, 29.93^{O}C and 29.73^{O}C for wards A, B, and C respectively. Temperature value primarily indicates good water quality, as it influences pH, alkalinity, acidity and dissolved oxygen (DO). Therefore, the temperature values recorded outstripped the WHO standard for drinking water and beyond the NSDWQ with the exception of the value recorded in ward A. Thus, this might unfavourably retard dissolution of oxygen and therefore, could amplify odour due anaerobic reaction (less oxygen), with which the water conceivably unwholesome for drinking.

From the results of this study, the levels of pH recorded were 5.64±0.78, 6.74±0.51 and 6.60±0.17 for ward A, B and C, respectively. Water with a low pH is regarded as acidic, soft and corrosive and could leach metals such as copper, iron, lead, manganese and zinc from pipes and fixtures. It can also cause damage to metals pipes and brings about aesthetic problems such as a metallic sour taste, laundry staining or blue–green stains in sinks and drains. Therefore, the waters might contain elevated levels of toxic metals, with which could be detrimental human health. All the mean pH values recorded in this investigation however fall within the limits of 6.5 – 8.5 and 6.5-9.5 recommended by NSDWQ and WHO, respectively.

The results of the analysis have indicated that the mean values of Electrical Conductivity were 272.0µS/cm, 116.7µS/cm and 553.3µS/cm for wards A, B and C, respectively. The conductivity value of the wash-borehole waters is a useful indicator of their salinity or salt contents. Conductivity values of water samples collected from all the three wards, therefore, fall within the acceptable limits set by NSDWQ and WHO and as a result, the wash-borehole waters analytically examined were sanitarily befitted for consumption to this regard.

Turbidity is caused by suspended matter or impurities that interfere with the clarity of the water. These impurities may include clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds, and plankton and other microscopic organisms. Laboratory analysis revealed that the mean turbidity values of the wash-borehole water were 7.76NTU, 9.02NTU and 14.15NTU for ward A, B and C, respectively. This means that the wash-borehole water samples from all the study sites are not suitable for human consumption, as their turbidity values exceeded the maximum allowable limit recommended by both the national and international drinking water regulatory authorities. Excessive turbidity in drinking water, apart from being aesthetically unappealing, may also present a health threat by providing food and shelter to pathogens.

The results of the analysis revealed that wash-borehole water samples obtained from the three wards A, B and C had their mean concentration of Total Dissolved Solids (TDS) as 136.0mg/L, 58.42mg/L and 276.67mg/L, respectively. TDS is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonates, bicarbonates, chloride, sulphate, and nitrate anions (WHO, 2003). As far as TDS is concern, the wash-borehole water samples in all the three wards showed not any health threat, because their values fall within the acceptable limits of 500mg/L and 1000mg/L set by the NSDWQ and WHO, respectively.

Ward A had a mean nitrate concentration of 33.80mg/L, while wards B and C had mean concentrations of 21.80mg/L and 23.34mg/L, respectively. A comparison with the guideline given by NSDWQ (50mg/L) showed that the nitrate concentration in all the water samples were within the recommended limit. In contrast, the NO_3^-levels in the waters exceeded the tolerable limit set by WHO (10mg/L), which suggested that there was an indication of NO_3^- pollution in the water sources. The high concentration of NO_3^- in the wash-borehole water might be attributed to the intrusion and contamination of nitrogenous wastes coined from dumped wastes and human waste from proximate dump sites and pit latrines, of which their locations were not considered prior to the construction of the boreholes. As such, the water from those sources is not suitable for drinking, as it could support algal growth, which in turn might be detrimental to human health.

Although the NO_3^- contents of the water falls within the NSDWQ acceptable limits, but beyond the WHO recommended limits. However, upon the NSDWQ gauge, further analysis revealed that there was high concentration of NO_2^- in excess. The highest mean value of NO_2^- was detected in water collected from ward A (0.76mg/L) followed by ward C (0.66mg/L) and then ward B with a mean value of 0.47mg/L. In contrast, all the mean values of the three wards were quite below the WHO standards. This might be attributed to the fast chemical transformation of NO_2^- to NO_3^- via oxidation process. Thus, as the wash-borehole water samples had excessive concentration of nitrite above the recommended limit of 0.2mg/L set by NSDWQ guidelines. The major health concern related to high level of nitrite in drinking water is that nitrite is capable of oxidizing iron in the hemoglobin of the red blood cells to form methemoglobin, which lacks the oxygen-carrying ability of hemoglobin. This creates the condition known as methemoglobinemia (sometimes referred to as "blue baby syndrome"), in which blood lacks the ability to carry sufficient oxygen to the individual body cells causing the veins and skin to appear blue. Most humans over one year of age have the ability to rapidly convert methemoglobin back to oxyhemoglobin; hence, the total amount of methemoglobin within red blood cells remains low in spite of relatively high levels of nitrite uptake. However, in infants under six months of age, the enzyme systems for reducing methemoglobin to oxyhemoglobin are incompletely developed and methemoglobinemia can occur. This also may happen in older individuals who have genetically impaired enzyme systems for metabolizing methemoglobin (Water research, 2011).

The mean SO_4^{2-} concentrations in water samples were5.67mg/L for ward A, 2.01mg/L for ward B and 21.82mg/L for ward C. The sulphate values in water samples collected from all the three wards were quite below 100mg/L recommended limits set by both national and international drinking water regulatory authorities.

Ward A had a mean phosphate value of 1.12mg/L, while wards B and C had their mean phosphate values as 0.07mg/L and 10.82mg/L, respectively. The water collected from wards A and B can safely be used for drinking purposes. However, the use of water collected from ward C for similar purpose could have health implications, because it contains phosphate at a level higher than the recommended value of 5.0mg/L set by WHO and NSDWQ. The high value recorded in ward C might be inclined to the sewage seepage and contamination from proximate drains which contained wastewater containing phosphate, as we witnessed activities such as washing of clothes, motorcycles and cars within vicinity of the wash-borehole. Thus, the water is not hygienic for drinking, as it could support algal growth and other plankton. Therefore, as a preventive measure, as suggested by Oparaocha et al. (2011), such activities should be discouraged nearby boreholes as that may result in infiltration of detergents and other chemicals into the aquifers.

No fluoride was detected in water samples obtained from ward A. However, in ward B and C mean fluoride concentrations of 0.80mg/L and 0.40mg/L were recorded, respectively. The use of wash-borehole water obtained from the metropolis for drinking purposes is not, therefore, likely to cause any fluoride-related health problem as the fluoride values were not beyond the acceptable limits of 1.5mg/L recommended by WHO and NSDWQ.

The hardness of drinking water is determined largely by its content of calcium and magnesium. It is expressed as the equivalent amount of calcium carbonate that could be formed from the calcium and magnesium in solution. The mean values for hardness were 2.42mg/L, 0.95mg/L and 2.33mg/L for wards A, B and C, respectively. Thus, the wash-borehole waters showed their suitability for drinking, as their values were far below the recommended limits given by NSDWQ and WHO as 150mg/L and 200mg/L, respectively.

Another parameter analysed in this investigation was the Total Iron. Iron is considered as secondary or "aesthetic" contaminant. The level of Iron in wash-borehole water in ward A (0.14 mg/L) was within the NSDWQ and WHO agreed limits of 0.3 mg/L. However, the levels in wards B (0.93mg/L) and C (0.79mg/L) were above the recommended limits approved by WHO and NSDWQ.The WHO and NSDWQ recommended limits for iron in drinking water is based on taste and appearance. Therefore, water obtained from wards B and C might not be suitable for drinking and other domestic purposes, because Iron concentration above the recommended limitsis known to impart bitter metallic taste and offensive odour on the water. It also leads to staining of glassware, dishes and household fixtures such as sinks and thus, reducing its palatability and overall suitability and acceptability.

The levels of copper (Cu) were not detected in the water samples collected from wards A and B. Even in ward C, the amount detected (0.05mg/L) was very low and far below the recommended limits of 1.0 mg/L set by both WHO and NSDWQ. The manganese concentrations, 0.20mg/L, 0.06mg/L and 0.09mg/L for wards A, B and C, respectively, fall within the desired limit of 0.2mg/L recommended by the NSDWQ. Therefore, the levels of copper in the wash-borehole water in the metropolis are not likely to cause any significant impact on human health. However, the level of manganese (Mn) in the wash-borehole water sampled from ward A was twice the approved limit set by WHO. Consequently, the high level may lead to low IQs, as at very high exposures it is a neurotoxin (has adverse effects on the brain) (Health Canada, 2007). Besides, high level of manganese in drinking water impacts undesirable taste and other aesthetic problems just like the case of iron.

Coliform bacteria are described and grouped based on their common origin or characteristics, as either total or faecal Coliforms. The total group includes faecal Coliform bacteria such as *Escherichia coli (E .coli)*, as well as other types of Coliform bacteria that are naturally found in the soil. Faecal Coliform bacteria exist in the intestines of warm blooded animals and humans, and are found in bodily waste, animal droppings, and naturally in soil. Most of the faecal Coliform in faecal material comprised of *E. coli*, and the serotype *E. coli* 0157:H7 is known to cause serious human illness (Health Canada, 2011). The bacteriological analysis revealed no total Coliform in water samples obtained from ward C. However, in ward A and B, the mean values of 0.03CFU/100ml and 1.00CFU/100ml were obtained. Water samples from all the three wards contained no feacal Coliform. The NSDWQ recommends that drinking water may contain up to 10CFU/100ml total Coliform CFU/100ml, but WHO recommended<10CFU/100ml. Similarly, both WHO and NSDWQ recommend no feacal coliform should be found in any water meant for drinking. Based on bacteriological analysis, therefore, one may conclude that wash-borehole water samples from all the three wards met the suitability requirements for drinking and domestic purposes, as no faecal coliform bacteria were detected in them and there were very low total coliform counts far less than the 10CFU/100ml set by WHO and NSDWQ.

Conclusion and Recommendation

The result of the present study revealed that quite a number of the water quality parameters investigated fall within the acceptable limits set by the Nigerian regulatory authority (NSDWQ) and world health organization (WHO). However, the water obtained from the wash-boreholes if use for drinking purpose could bring about some health problems. This is because the water from all the three wards contained high levels of turbidity and nitrite (NO_2^-) above the limits recommended by the Nigerian regulatory authority for drinking water and also, contained level of nitrate (NO_3^-) beyond the WHO limit. The continuous use of water from the wash-boreholes in Gombe metropolis could, therefore, lead to outbreak of especially gastroenteritis diseases. The public should be properly educated on the dangers associated with drinking turbid water. They should be enlightened on the need to allow debris and other particles to settle down at the bottom of the water container before use. The community should be encourage to adopt the use of simple water purification technology such as the use of local plant Moringa olifera (Mangale *et al*, 2012) which speed up sedimentation of particle in the water before drinking.

As a preventive measure to reduce the health threat associated with consumption of the nitrite, nitrate, phosphate, manganese and iron contaminated water, it is recommended that wash-boreholes water within Gombe metropolis should be used for bathing and washing only, and people should be provided with alternative water source for drinking and cooking purposes. In addition, there should be a continuous monitoring of wash-borehole water by the relevant constituted authority in order to detect any changes in the water quality. Activities such as washing of cloths, motorcycles, and cars within the borehole vicinity should be discouraged as that may have resulted in the infiltration of detergents and other chemicals into the aquifers, which probably account for the high concentration of phosphate in the borehole water.

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Table1. Mean values and Standard Deviation of physicochemical and bacteriological parameters in wash-borehole water samples obtained from different wards in Gombe Metropolis compared to the recommended Nigerian Standard for Drinking Water Quality (NSDWQ) and World Health Organisation (WHO).

Parameters	**Wards**				
	A	**B**	**C**	**NSDWQ**	**WHO**
Temperature (^{o}C)	26.38 (± 1.36)	29.93 (± 0.19)	29.73 (± 0.19)	27.0 –28.0	25
pH	5.64 (±0.78)	6.74 (± 0.51)	6.60 (± 0.17)	6.5 -8.5	6.5-9.5
Conductivity (µS/cm)	272.0 (±56.89)	116.7 (± 25.81)	553.3 (± 107.8)	1000	1000
Turbidity (NTU)	7.76 (± 0.09)	9.02 (± 9.13)	14.15 (±7.73)	5.0	5.0
Total Dissolved Solids (mg/L)	136.0 (±29.94)	58.42 (± 12.85)	276.67 (± 53.19)	500	1000
Nitrate (mg/L)	33.80 (±12.19)	21.80 (±18.01)	23.34 (±12.10)	50	10
Nitrite (mg/L)	0.76 (±0.19)	0.47 (± 0.57)	0.66. (± 0.80)	0.2	3.0
Sulphate (mg/L)	5.67 (±2.25)	2.01 (±3.10)	21.82 (± 20.14)	100	100
Phosphate (mg/L)	1.12 (±0.29)	0.07 (± 0.14)	10.82 (±11.12)	5.0	5.0
Flouride (mg/L)	ND	0.80 (± 0.82)	0.40 (± 2.28)	1.5	1.5
Hardness (mg/L)	2.42 (±0.81)	0.95 (±0.24)	2.33 (± 0.08)	150	200
Total Iron (mg/L)	0.14 (±0.81)	0.93 (±0.13)	0.79 (±0.65)	0.3	0.3
Copper (mg/L)	ND	ND	0.05 (±0.10)	1.0	1.0
Manganese (mg/L)	0.20 (±0.01)	0.06(±0.01)	0.09 (±0.06)	0.2	0.1
Total coliform CFU/100 ml	0.03 (± 0.07)	1.00 (±1.03)	ND	10	<10
Feacal coliform CFU/100 ml	ND	ND	ND	0.00	0.00

ND = Not Detected A = Tudun Wada B = Pantami C = Jeka da Fari